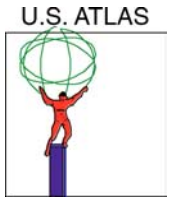


Liquid Argon Calorimeter

Richard Stroynowski

SMU

US ATLAS Calorimeter Groups

Subsystem Manager

R. Stroynowski

Representatives on US Executive Committee

D. Lissauer, J. Parsons, J. Rutherfoord, R. Stroynowski

University of Arizona

T. Embry, K. Green, P. Loch, J. Rutherfoord *, A. Savin, L. Shaver, M. Shupe, M. Starr, D. Tompkins, P. Truncale

Brookhaven National Laboratory

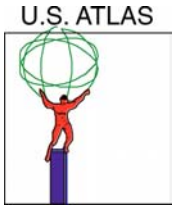
C. Chen, H.A. Gordon, B. Hackenberg, S. Kane, J. Kierstead, F. Lanni, M. Leite, D. Lissauer*, H. Ma, D. Makowiecki, T. Muller, S. Norton, P. O'Connor, L.Premisler, V. Radeka, S. Rajagopalan, M. Rehak, S. Rescia, J. Sondericker, I. Stumer, H. Takai, K. Wolniewich, K.C. Wu, K. Yip

Columbia University (Nevis Laboratory)

J. Ban, C.Y. Chi, J. Dodd, R. Gardner, I. Katsanos, M. Leltchouk, S. Negroni, J. Parsons*, S. Simion, W. Sippach, A. Teho, W.J. Willis, L. Zhang

University of Pittsburgh

W.E. Cleland*, J. McDonald, M. Lawrence, B. Liu, V. Paolone, J. Rabel, V. Savinov, G. Zuk



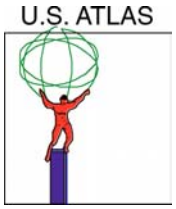
US ATLAS Calorimeter Groups

Southern Methodist University
E. Barberio, G. Evans, Y. Gao, M. Knee, L. Lu, T. Liu, R. Stroynowski*, J. Ye, P. Zarzhitsky

University of Stony Brook
B. Botchev, R. Engelmann, A. Khodinov, R. McCarthy, R.D. Schamberger, M. Rijssenbeek*, J. Steffens, A. Talalaevskii, H. Themann, M. Thioye

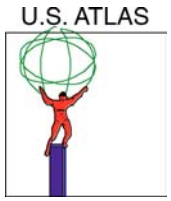
University of Rochester
P. Slattery*

***Institutional Leaders**



US Leadership Roles

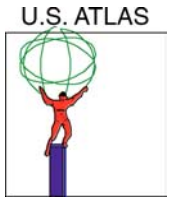
- US has overall leadership roles in:
  - LAr Electronics Coordination (Cleland, Parsons)
    - FEB (Parsons)
    - Optical Links (Ye)
    - Front End Crate (Lanni)
  - Forward Calorimeter (Rutherfoord)
  - Cryogenics Control System (Sondericker)
  - Offline Software (Rajagopalan)



Liquid Argon Calorimeter

US Responsibilities (Status May 02)

1.3.1 Barrel cryostat	construction completed, integration continues
1.3.2 Feedthroughs	
1.3.2.1 Signal FT	completed and installed (barrel)
1.3.2.2 High Voltage FT	production completed, barrel installation started
1.3.3 Cryogenics	in production, control software in design stage
1.3.4 Electrodes	
1.3.4.1 Readout electrodes	completed
1.3.4.2 Mother Boards	completed
1.3.5 Preamps	in production
1.3.6 System Crates/ Integration	
pedestals, crates	in production
power supplies, cooling	prototypes exist
1.3.7 FEBs and Optical Links	prototype exists, components exist, schedule delays
1.3.8 Level 1 Trigger Sums	prototype exists, summing boards complete
1.3.9 Readout Driver	prototype stage
1.3.10 Forward Calorimeter	FCalC complete, FCalA in production, installation delays
1.3.11 Test Beams	on-going, special electronics needs



Liquid Argon Calorimeter

US Responsibilities (Status May 03)

1.3.1	Barrel cryostat	construction completed, integration continues
1.3.2	Feedthroughs	
1.3.2.1	Signal FT	completed and installed (barrel)
1.3.2.2	High Voltage FT	completed, barrel + endcapC installed
1.3.3	Cryogenics	in production, control software in design stage
1.3.4	Electrodes	
1.3.4.1	Readout electrodes	completed
1.3.4.2	Mother Boards	completed
1.3.5	Preamps	completed
1.3.6	System Crates/ Integration	
	pedestals, crates	completed
	power supplies, cooling	prototypes exist
1.3.7	FEBs and Optical Links	components exist, integration to be verified
1.3.8	Level 1 Trigger Sums	prototype exists, summing boards complete
1.3.9	Readout Driver	prototype stage
1.3.10	Forward Calorimeter	construction completed, calibration ongoing
1.3.11	Test Beams	on-going, special electronics needs

US Deliverables

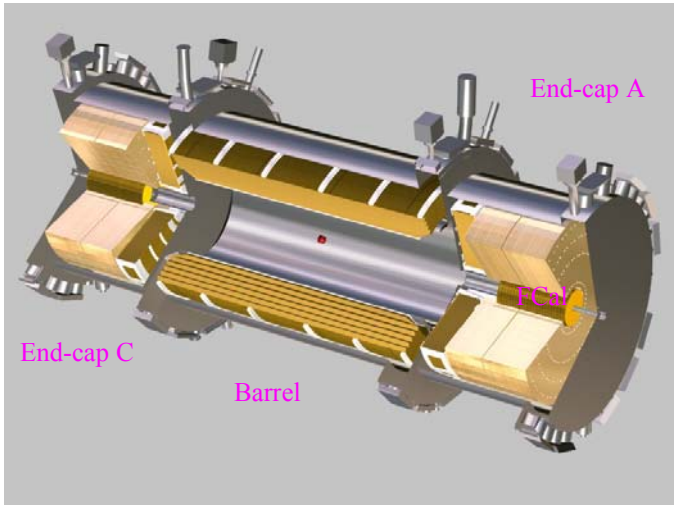
Mechanical components:

Cryostat, cryogenics, LN2 system

Feedthroughs (signal+HV), cables

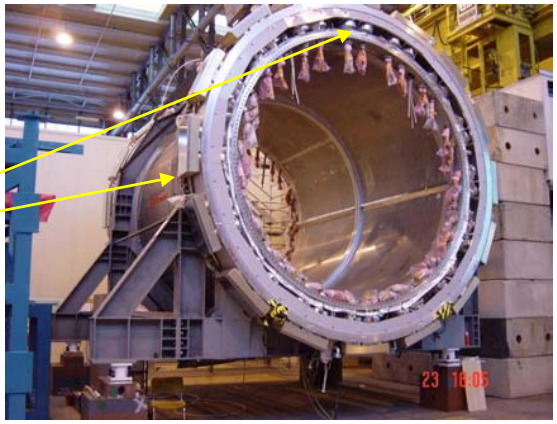
Electrodes, Forward calorimeter

Diagnostics and slow controls



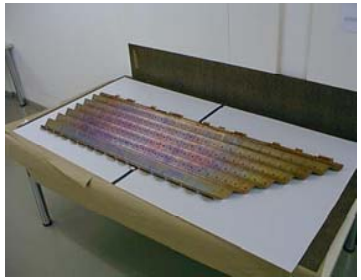
Barrel cryostat

Feedthrough
Pedestal

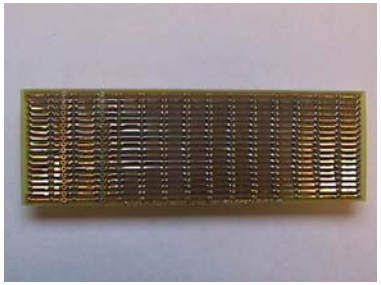


Quality meter

Electromagnetic modules

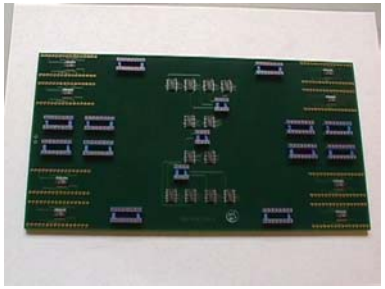


Electrodes

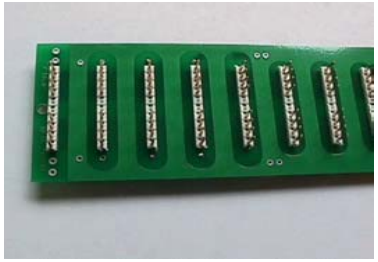


Summing boards

Module assembly (at CERN)

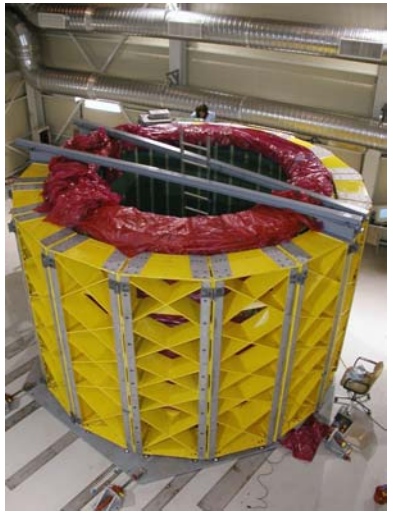


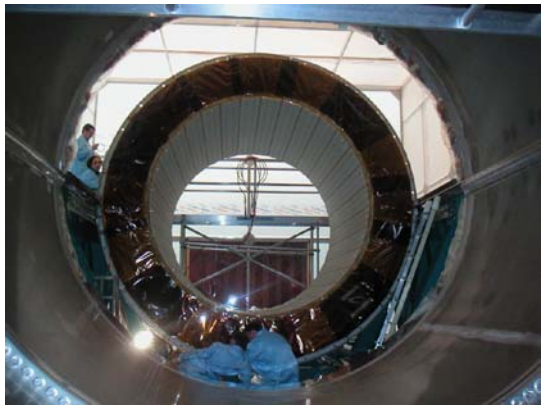
Mother boards



HV boards

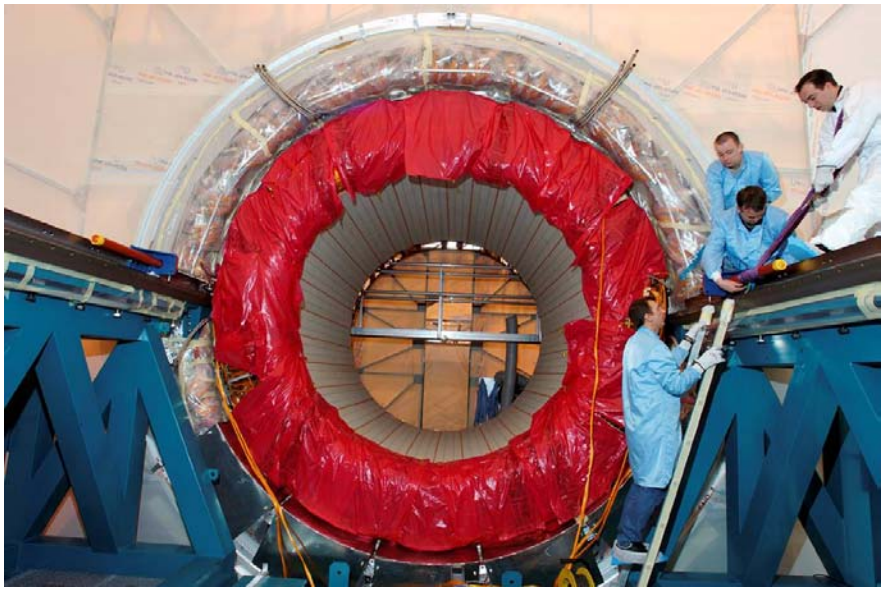
Half-barrel wheel assembly
16 modules





Installation into the cryostat

Electromagnetic modules



Barrel EM installed

Endcap EM on insertion stand

US Deliverables

End-cap feedthroughs and pedestals

FCal 1A

FCal-C
(all sections)

Front-end readout

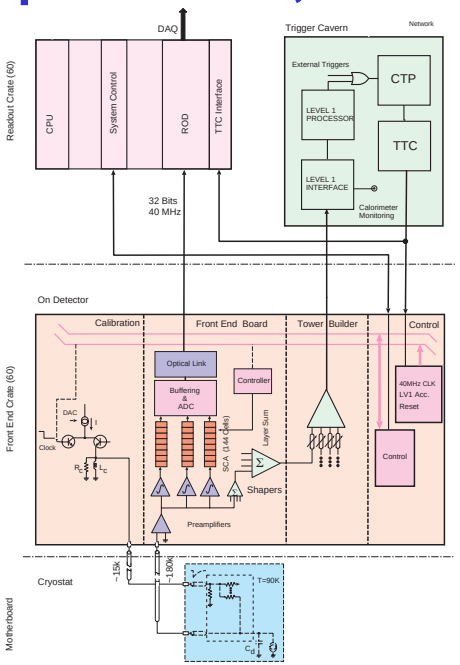
1600 Front-end boards

9 types of ASIC chips

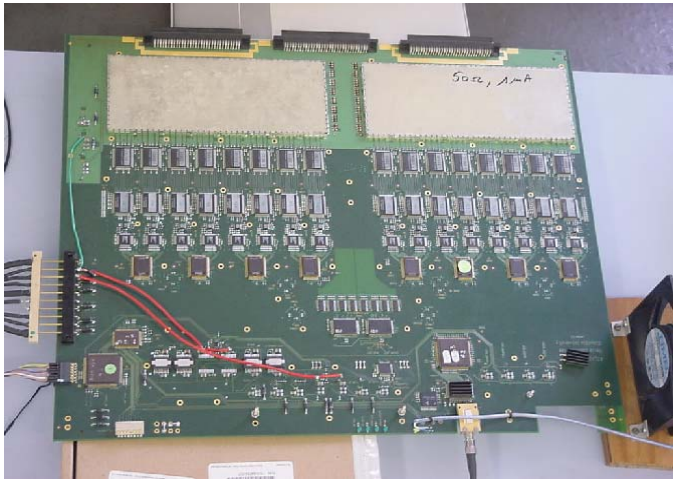
hybrid preamps

layer sum boards

optical links, cooling plates



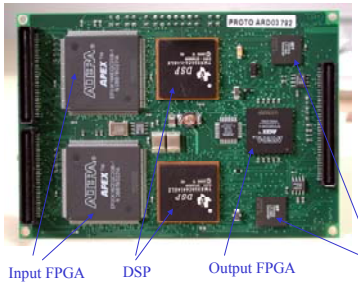
FEB prototype



Preamps

Layer sum board

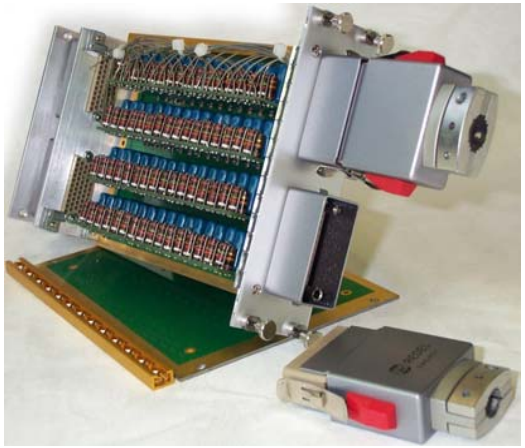
Optical link



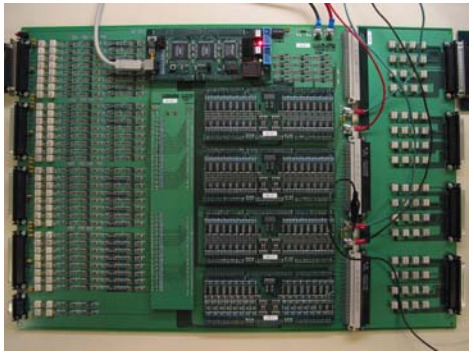
ROD processing unit

Electrical and electronics components

64 Front-End Crates+ Services
Power Supplies
LV1 Receiver (8 VME crates)
HV Filters



HV Filter box



LV1 Receiver board

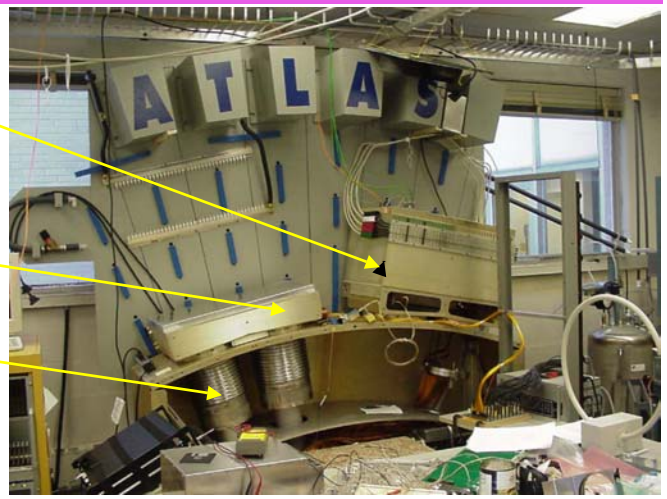
Cooling plate

Variable Gain Amplifier

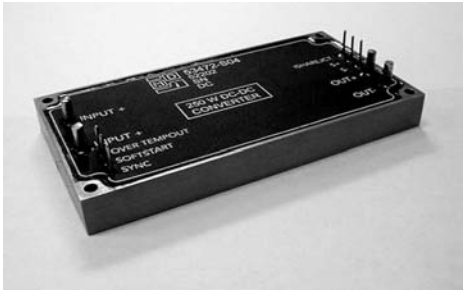
Front-end crate
28 FEBs, calibration,
tower builder,
Controller, clock distr.

Base plane+pedestal

Feedthrough



Crate test setup



DC-DC converter brick
(18 in a power supply unit)

System Status

- **Mechanical components** –close to completion
  - Production of electrodes and motherboards done
  - Endcap-C cryostat tested, feedthroughs installed, Endcap A delivery in June.
  - Barrel cryostat, signal+HV feedthroughs, pedestals, half-wheel of modules installed (second half wheel will be completed in June)
  - Fcal C – cabled and fully tested, Fcal A construction completed (delivered to CERN)
  - Cryogenics components
    - Quality meters – production completed, installation for the temporary system in Bldg. 180 – done
    - LN2 compressor delivered to CERN
    - Control software - under development

System Status

- **Electronics**
  - Design and prototype of Front-End Board exists. Pre-production series (20 boards) is submitted.
  - Most of the components exist or are in production: preamps, shapers, G-links, COTS, positive voltage regulators, re-mapping boards…
  - Power supplies – prototype in production
  - Crates – production completed
  - Concerns:
    - Negative voltage regulators – fourth (and hopefully final) version will be available in June. Delivery of production series – October
    - DMILL production of ASICS chips not yet complete (all have been submitted). The company contracted to complete production by December 2003 and the DMILL process will no longer be available after the end of the year. Any single chip missing would require major redesign of the board.

Critical Milestones

• Barrel calorimeter installation will be completed	Sep. 03
Transport to the pit	Oct. 04
• End-cap C calorimeter installation completed	Feb. 04
Transport to the pit	Oct. 04
• End-cap A calorimeter installation completed	Feb. 05
Transport to the pit	May 05
• LN2 system completed	Apr. 05
• Readout electronics	
Pre-production series of 20-30 boards	May 03
Production completed	Aug. 04
Installation and commissioning in the pit	Dec. 04 – Apr. 06

Research program (M&O) includes:	
Pre-operations	03-06
Beam tests	04-05
Operations and maintenance	07-

Transition Status

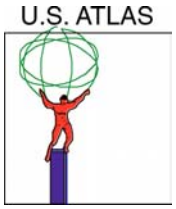
- Construction project and pre-operations overlap for the next two years.
- After installation of the calorimeter modules each cryostat will be closed, cooled down and run with temporary cryogenics. The modules will be tested with portable electronics before welding the cryostat shut for transport to the pit.
- Full crate test will be done before launching full scale FEB production.
- FCal calibration beam run and hadronic shower tails measurement will be completed in 2004.

FCal beam test assembly

Pre-operations

- Operations of the cryogenics system in the West Hall (cryostats, feedthroughs, temporary refrigeration system) (04-05)
- Documentation update
- Transport to the pit (04-05)
- Integration with magnet and TileCal
- Calibration beam test of the FCal (04) and hadronic tail measurements in the combined FCAL/EMEC/HEC (05) run
- Full crate test of readout electronics at BNL (03-05)
- Portable readout electronics for calorimeter testing in the West Hall


EC HV FT



Next Year

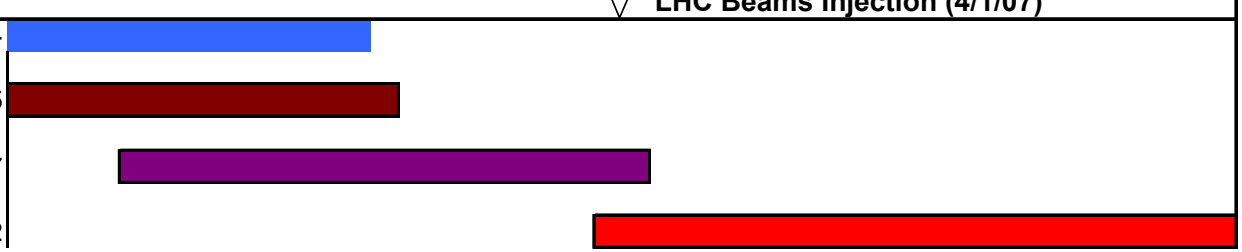
Major elements of the Construction Project during the next year:

- **Front-End Board production**
- **Level-1 Receiver system production**
- **Power supplies production**
- **Cryogenics controls and software development**

U.S. ATLAS: High Level Schedule

U.S. ATLAS
Level 2
Construction/Research Program Transition Schedule

Subsystem	Category	Start Date	Compl Date
LAr	Construction	N/A	10/19/04
	Installation	10/1/01	2/14/05
	Pre-Operations	10/1/02	6/30/07
	Operations	1/2/07	9/28/12

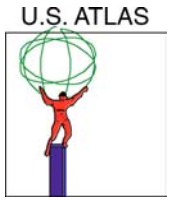


Conclusions

- Over past year many problems encountered and solved: dropped FCal module, endcap cryostat stops and FT holes, FEB voltage regulators, FEB timing margins…
- Rapid progress towards end of production of all mechanical components: cryostat, cryogenics, modules, FCal
- Many electronics components exist on hand: crates, preamps, G-links, re-mapping boards.
- Ready to start pre-production of front-end electronics.
- Production schedule for FEB is tight but within overall ATLAS schedule
- Still on budget

Major elements of the Construction Project during the next year:

- Front-End Board production
- Level-1 Receiver system production
- Power supplies production (still in Management Contingency)
- Cryogenics controls and software development



Subsystem Breakout

Liquid Argon Calorimeter

ETC 03 Cost Comparison
Liquid Argon - WBS Level 3

(Project AYk$s)			
	Prel ETC03 Total Budget (ETC02 FY03-FY05 + Carryover)	Final ETC03 (FY03 - FY05)	
WBS	Total Budget (AYk$s)	Total Budget (AY$s)	Delta
131	816.6	923.94	(107.4)
132	699.8	180.62	519.1
133	1,930.5	1,867.83	62.7
134	674.9	511.85	163.0
135	129.1	150.59	(21.5)
136	2,190.5	2,220.32	(29.8)
137	5,743.1	6,079.34	(336.2)
138	1,256.6	1,177.13	79.5
139	274.1	281.56	(7.5)
1310	454.8	689.53	(234.7)
1311	563.0	471.43	91.6
Total	14,732.9	14,554.12	178.8

Cost changes in ETC03

- 1.3.1 Cryostat – chimney weld repairs, calculations needed for installation and integration
- 1.3.7 FEB – delays due to voltage regulators and DMILL production, additional radiation testing requirements
- 1.3.10 FCal – partly accounting swap with 1.3.11 (Beam test), accident recovery

ETC 03
Institution Projection Totals by Year

ETC03 Funding Projections for Liquid Argon (Project k$s)				
Institution	**FY03**	**FY04**	**FY05**	**Total**
BNL - Cryostat	1,731.0	550.1	471.1	2,752.2
BNL_	1,770.6	1,291.8	274.3	3,336.7
Columbia U. (Nevis Laboratory)	3,231.7	2,283.4	311.9	5,827.0
Southern Methodist U.	176.7	-	-	176.7
SUNY Stony Brook	201.9	23.1	9.7	234.7
U. of Arizona	603.5	205.2	69.9	878.6
U. of Pittsburgh	419.1	381.7	347.7	1,148.5
Total	8,134.5	4,735.3	1,484.6	14,354.4

ETC 03 Cost Profile
Liquid Argon - WBS Level 3

Liq Argon ETC 03 Access Profile (Project K$s)				
WBS	**FY03**	**FY04**	**FY05**	**Total**
131	261.7	261.7	373.5	897.0
132	166.8	13.4	0.0	180.3
133	1,469.3	288.4	97.6	1,855.3
1341	250.0	0.0	0.0	250.0
1342	261.8	0.0	0.0	261.8
1351	150.6	0.0	0.0	150.6
136	930.6	986.7	263.8	2,181.2
137	3,299.3	2,403.5	300.0	6,002.8
138	419.1	381.7	347.7	1,148.6
139	186.7	59.6	32.0	278.3
1310	437.5	174.0	69.9	681.4
1311	301.0	166.3	0.0	467.3
1.3 Total (FY03$s)	8,134.5	4,735.4	1,484.6	14,354.5
1.3 Total (AY$s)	8,134.5	4,853.7	1,565.8	14,554.1

Liquid Argon Milestones

Level 2 Milestones

Subsystem	Schedule Designator	Description	ETC 02 Schedule Date	ETC 03 Schedule Date
Liquid Argon	LAr L2/1	Cryostat Contract Award	Complete	Complete
	LAr L2/2	Barrel Feedthroughs Final Design Review	Complete	Complete
	LAr L2/3	Start Elec.'s Production (Preamps)	Complete	Complete
	LAr L2/4	FCAL Mech Design Complete	Complete	Complete
	LAr L2/6	Level 1 Trigger Final Design Complete	Complete	Complete
	LAr L2/7	ROD Final Design Complete	12-Dec-02	15-Aug-03
	LAr L2/8	MB System Production Complete	30-Sep-02	Complete
	LAr L2/9	Cryostat Arrives at CERN	Complete	Complete
	LAr L2/10	Barrel Feedthroughs Production Complete	Complete	Complete
	LAr L2/11	FCAL-C Delivered to EC	15-Jan-03	1-Dec-03
	LAr L2/12	FCAL-A Delivered to EC	4-Nov-03	15-Jul-04

Liquid Argon Milestones

Level 4 Milestones (Baseline Scope)

WBS	Schedule Designator	U.S. ATLAS Responsibility Completion Description	ETC 02 Baseline Scope Completion Date	ETC 03 Baseline Scope Completion Date	ATLAS Required Date	ETC 03 Planned Float (Months)
LAr						
1.3.1	LAr L4/1	Cryostat Final Accep Test Compl	Complete	Complete	11/01	N/A
1.3.2	LAr L4/2	Signal FT Installation Compl	Complete	Complete	10/02	N/A
	LAr L4/3	HV FT End-Cap C Install Compl	9/02	7/03	7/03	**0**
	LAr L4/4	HV FT Barrel Install Compl	5/02	12/02	12/02	**0**
	LAr L4/5	HV FT End-Cap A Install Compl	9/03	12/03	6/04	6
1.3.3	LAr L4/6	LAr Cryogenics Vendor Install Compl	9/03	9/05	9/05	**0**
1.3.4.1	LAr L4/7	Last Del of Readout Electrodes	12/02	1/03	3/03	2
1.3.4.2	LAr L4/8	MBs Ship to Annecy,Saclay (France)	Complete	Complete	3/03	N/A
1.3.5.1	LAr L4/9	Preamp Deliveries to FEB Compl	5/03	5/03	3/04	10
1.3.6.1	LAr L4/12	Barrel Pedestal Ship to CERN Compl	10/02	Complete	7/03	N/A
	LAr L4/13	EC Pedestal Ship to CERN Compl	10/02	7/03	9/03	2
1.3.6.2	LAr L4/14	Cables Shipping Complete	10/02	7/03	9/03	2
	LAr L4/15	Baseplane Last Delivery to CERN Compl	10/02	7/03	9/03	2
1.3.6.3	LAr L4/16	EC Crates Last Delivery to CERN Compl	10/02	7/03	10/04	15
	LAr L4/17	Barrel Crates Last Delivery to CERN Compl	10/02	10/03	10/04	12
1.3.6.5	LAr L4/21	Thermal Contacts (Proto) Last Delivery Compl	9/02	9/03	10/03	1
1.3.7.1	LAr L4/22	FEB Last Delivery Complete	10/04	9/05	12/05	3
1.3.7.4	LAr L4/24	Last Driver Delivery to FEB Compl	4/04	4/04	5/04	1
1.3.8.1	LAr L4/26	Layer Sums Last Delivery to FEB Compl	12/02	3/04	3/04	0
1.3.8.2	LAr L4/27	I/F to Level 1 Ship to CERN Complete	9/04	3/05	9/05	6
1.3.9	LAr L4/28	ROD System Final Prototype Complete	8/02	9/04	9/05	12
1.3.10	LAr L4/29	Deliver Finished FCAL-C to EC	1/03	12/03	1/04	1
	LAr L4/30	Deliver Finished FCAL-A to EC	11/03	7/04	8/04	1
	LAr L4/31	FCAL Elec.'s Summ Bds Ready for Installation	7/02	8/03	12/03	4
	LAr L4/32	FCAL Elec.'s Cold Cables Testing Complete	Complete	Complete	2/02	N/A